(19) JAPANESE PATENT OFFICE

PATENT ABSTRACTS OF JAPAN

(11) Publication number: **05009509 A**
(43) Date of publication of application: **19.01.1993**

(51) Int. Cl **B22F 7/00**
B22F 3/14, C22C 38/00, C22C 38/00, F27B 17/00

(21) Application number: **03187052**
(22) Date of ling: **02.07.1991**

(71) Applicant: **HAYASHI KOJI**
NACHI FUJIKOSHI CORP

(72) Inventor: **HAYASHI KOJI**
KARAKI MICHIO
YAMAZUMI UMIMORI

(54) SINTERED BODY OF HIGH-ALLOY TOOL STEEL AND PRODUCTION THEREOF

(57) Abstract:

PURPOSE: To obtain the sintered body of the high-alloy tool steel which is free from structural defects in material, such as formation of coarse crystal grains, formation of macrocarbides arising from the melting and aggregating of carbides, and is free from material defects, such as holes, after sintering.

CONSTITUTION: Fine particles of the high-alloy tool steel having the grain sizes ranging from $<10^1$ up to $10^{-2}\mu m$ are incorporated at 20 to 80% into 80 to 20wt.% coarse particles of the high-alloy tool steel having 10^1 to $<10^3\mu m$ grain sizes, by which a dense characteristic of 100% relative density is obtd. Further, the above-mentioned powder is compacted and molded and the molding is subjected to a solid phase sintering treatment for about 120 minutes at 1503 to 1573K temp. in a vacuum atmosphere.

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-009509
(43)Date of publication of application : 19.01.1993

(51)Int.CI. B22F 7/00
B22F 3/14
C22C 38/00
C22C 38/00
F27B 17/00

(21)Application number : 03-187052
(22)Date of filing : 02.07.1991

(71)Applicant : HAYASHI KOJI
NACHI FUJIKOSHI CORP

(72)Inventor : HAYASHI KOJI
KARAKI MICHIO
YAMAZUMI UMIMORI

(54) SINTERED BODY OF HIGH-ALLOY TOOL STEEL AND PRODUCTION THEREOF

(57)Abstract:
PURPOSE: To obtain the sintered body of the high-alloy tool steel which is free from structural defects in material, such as formation of coarse crystal grains, formation of macrocarbides arising from the melting and aggregating of carbides, and is free from material defects, such as holes, after sintering.
CONSTITUTION: Fine particles of the high-alloy tool steel having the grain sizes ranging from <101 up to 10-2μm are incorporated at 20 to 80% into 80 to 20wt.% coarse particles of the high-alloy tool steel having 101 to <103μm grain sizes, by which a dense characteristic of 100% relative density is obtd. Further, the above-mentioned powder is compacted and molded and the molding is subjected to a solid phase sintering treatment for about 120 minutes at 1503 to 1573K temp. in a vacuum atmosphere.

LEGAL STATUS

[Date of request for examination] 25.05.1998
[Date of sending the examiner's decision of rejection] 27.02.2001
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平5－9509

(43)公開日　平成5年(1993)1月19日

(51)Int.Cl.⁵		識別記号	庁内整理番号	F I	技術表示箇所
Ｂ２２Ｆ	7/00	H	7803－4K		
	3/14		7803－4K		
Ｃ２２Ｃ	38/00	３０２　Ｅ	7217－4K		
		３０４	7217－4K		
Ｆ２７Ｂ	17/00	３０１　Ｅ	7308－4K		

審査請求　未請求　請求項の数4(全　6　頁)

(21)出願番号　特願平3－187052

(22)出願日　平成3年(1991)7月2日

(71)出願人　591162712
林　宏爾
埼玉県大宮市日進町1丁目297番地

(71)出願人　000005197
株式会社不二越
富山県富山市石金20番地

(72)発明者　林　宏爾
埼玉県大宮市日進町1丁目297番地

(72)発明者　唐木　道雄
富山県富山市石金20番地　株式会社不二越内

(74)代理人　弁理士　河内　潤二

最終頁に続く

(54)【発明の名称】　高合金工具鋼焼結体及びその製造方法

(57)【要約】

【目的】　結晶粒の粗大化や炭化物の溶融，凝集に伴う巨大炭化物の形成等の材料的な組織欠陥がなく、かつ焼結後に空孔等の材料欠陥のない高合金工具鋼焼結体を得る。

【構成】　粒径が10^1～10^3 μm未満の高合金工具鋼の粗粒粉８０～２０重量％に、粒径が10^1未満で10^{-2} μmまでの高合金工具鋼の微粉粒を２０％～８０％含むことにより、相対密度１００％の緻密特性を得る。さらに、上記の粉末を圧粉成形し、これを真空雰囲気で１５０３～１５７３Ｋの温度で約１２０分間固相焼結処理する。

【特許請求の範囲】

【請求項1】 粒径が10^1 ～10^3 μm未満の高合金工具鋼の粗粒粉８０～２０重量%に、粒径が10^1 μm未満で10^{-2} μmまでの高合金工具鋼の微粒粉を２０～８０％含み、相対密度１００％の緻密特性を有する高合金工具鋼焼結体。

【請求項2】 粒径が10^1 ～10^3 μm未満の高合金工具鋼の粗粒粉８０～２０重量%に、粒径が10^1 μm未満で10^{-2} μmまでの高合金工具鋼の微粒粉を２０～８０％配合し、次いでこれを圧粉成形し、さらに真空雰囲気中で１５０３～１５７３Ｋの温度で約１２０分間固相焼結処理し、相対密度１００％の緻密特性を得ることを特徴とする高合金工具鋼焼結体の製造方法。

【請求項3】 高合金工具鋼の合金粉末の粗粒粉に配合する微粉を粗粒粉と同一成分の合金粉末、又は組成中の単独元素の一種若しくは数種の微粉を混合した請求項２記載の高合金工具鋼焼結体の製造方法。

【請求項4】 高合金工具鋼の成分中の単独元素の粗粒粉を配合した混合粗粒粉に該混合粗粒粉と同一組成の合金粉末の微粉又は組成中の単独元素の一種若しくは二種以上の微粉を配合した混合微粉を混合した請求項２記載の高合金工具鋼焼結体の製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】この発明は、材料内部の微少欠陥等が問題となる切削工具用の高合金工具鋼焼結体及びその製造法に関する。

【０００２】

【従来の技術】粉末冶金法により高合金工具鋼焼結体を製造するには、ＣＩＰ装置を用いて圧粉体を成形しその後焼結したり、あるいはＨＩＰ装置を用いて直接焼結体を製造し、更にこの焼結体に鍛造、圧延等の塑性加工を加え、目的に応じて丸材、角材、板材及び線材、或いは所望の工具形状等に加工製造されている。かかる高合金工具鋼粉末焼結体に塑性加工を必要とするのは、通常焼結体には空隙、空孔等の欠陥があり、完全に緻密な焼結体を得ることは困難であるからであり、かかる焼結体に塑性加工を施してこれらを押しつぶし、空隙等の欠陥を改善して完全緻密化を計ることが必要である。

【０００３】例えば、粉末冶金法を用いる原料粉末には一般的に粉粒径が10^1 ～10^3 μm未満の粗粒粉或いは超微粉、ナノ微粉といわれる粉粒径が10^1 未満で～10^{-2} μmの粉末がそれぞれ単独で使われている。粗粒粉は圧粉体の成形時に空隙ができやすく、焼結時にこれらの空隙を除去して完全緻密化することは極めて困難である。また超微粉単独で圧粉体を成形する場合は、圧粉体の相対密度が高くなり過ぎるため、孤立空隙ができやすく、焼結後微細な空孔として残留する。

【０００４】

【発明が解決しようとする課題】本来、粉末冶金法の最も特徴とするところは、高い形状の自由度を有しているところにある。このため、高合金工具鋼の粉末を例えば丸材、角材、板材は勿論のこと、ドリル、エンドミル等の所望の工具形状の圧粉体に成形することも極めて容易である。その反面、焼結によって空孔等の材料欠陥が内部に残留することは不可避である。しかし、これらの欠陥を皆無にして完全に緻密化することは極めて困難であり、切削工具では材料内部の欠陥に基づくチッピング、欠損等が使用上問題となり、十分な工具性能は期待できない。従って工具製品形状の焼結体で実用化するには至っているものは殆どないのが現状である。

【０００５】一方、圧粉体を成形後、焼結温度を高くすることによって空孔等の欠陥は減少する傾向を示し、液相焼結においては気孔の残留が殆ど認められず、相対密度が１００％に近い焼結体を得ることが可能であるが、結晶粒の粗大化や炭化物の溶融、凝集に伴う巨大炭化物の形成等の材料的な組織欠陥を生じて材料の強靭性及び工具性能を著しく劣化させることになる。また、高合金工具鋼は、前記従来技術のように塑性加工を施して空隙等の欠陥を改善するものであるから、材料の歩留りが悪く、また多大の加工工数を必要とするのであり、きわめて高価となるという問題もあった。

【０００６】

【課題を解決するための手段】この発明は、粒径が10^1 ～10^3 μm未満の高合金工具鋼の粗粒粉８０～２０重量%に、粒径が10^1 未満で10^{-2} μmまでの高合金工具鋼の微粒粉を２０～８０％含み、相対密度１００％の緻密特性を有する高合金工具鋼焼結体、及び粒径が10^1 ～10^3 μm未満の高合金工具鋼の粗粒粉８０～２０重量%に、粒径が10^1 μm未満で10^{-2} μmまでの高合金工具鋼の微粒粉を２０～８０％配合し、次いでこれを圧粉成形し、さらに真空雰囲気中で１５０３～１５７３Ｋの温度で約１２０分間固相焼結処理し、相対密度１００％の緻密特性を得ることを特徴とする高合金工具鋼焼結体の製造方法に係わり、粉末冶金法の特徴である形状の自由度を維持すると共に、材料の緻密化を実現したものである。

【０００７】本発明において、粗粒径を10^1 ～10^3 μm未満としたのは、10^3 μm以上では組織、炭化物及び結晶粒が粗大となり、材料の強度劣化の原因となるからであり、また微粒径を10^1 未満で10^{-2} μmまでとしたのは、10^{-2} μmは技術的に製造可能な限界値であるからである。

【０００８】

【実施例】次に、本発明に係る実施例を説明する。図１は表１にＨ１乃至Ｈ６として示す各種の合金粉末の比較的粗い粒粉の高合金工具鋼成分を混合した各種の高合金工具鋼粉末であり、図１の上段は相対密度５４質量%、図１の下段は８４質量%の圧粉体のそれぞれの焼結温度と焼結体の相対密度の関係を示したものである。いずれも、真空炉で9×10^{1}～10^{-5}の真空度で１２０分間

固相焼結したものである。

【０００９】焼結体の相対密度は、成分組成及び圧粉体の密度によって異なるが、圧粉体の密度５４％では、Ｈ１＝１４７３Ｋ，Ｈ２＝１５４７Ｋ，Ｈ３＝１５２３Ｋ，Ｈ４＝１５５０Ｋ，Ｈ５＝１５０３Ｋ，Ｈ６＝１５３３Ｋの焼結温度で相対密度１００％の焼結体が得られるのに対し、圧粉体の密度８４％では、Ｈ１＝１４７３Ｋ，Ｈ２＝１５２３Ｋ，Ｈ３＝１５０３Ｋ，Ｈ４＝１５４７Ｋ，Ｈ５＝１５０３Ｋ，Ｈ６＝１４７３Ｋで、相対密度１００％の焼結体が得られ、Ｈ１，Ｈ５成分のものを除き、圧粉体の密度の高い方が低い焼結温度で相対密度の高い焼結体が得られることが示される。また、焼結温度が高くなると相対密度が高くなる傾向も同時に示すもので、このことは成分組成の液相温度の高低も関連しているものと考えられる。この場合、比較のために水素雰囲気による固相焼結を行ったところ、相対密度が９５～９７％で飽和または最大となり、少量の孤立空隙が残留することが確認された。

【００１０】

【表１】

（重量％）

合金粉末		Ｆｅ	Ｃｏ	Ｃ	Ｃｒ	Ｍｏ	Ｗ	Ｖ	ＴｉＮ
Ｈ１	○	73.63	7.87	1.24	3.90	9.79	1.60	1.19	－
Ｈ２	□	79.14	0.56	1.33	3.97	5.57	5.78	3.07	－
Ｈ３	△	71.76	8.22	1.35	3.99	5.13	6.25	2.67	－
Ｈ４	⬡	70.65	5.02	1.78	4.09	0.40	12.48	4.88	－
Ｈ５	▽	62.03	9.40	2.86	4.01	3.45	9.38	8.31	－
Ｈ６	×	53.41	8.46	3.05	4.05	3.23	9.76	7.54	10

【００１１】相対密度１００％に至る焼結温度は成分配合によって異なるが、表１のＨ２の合金粉末を焼結する場合では１５２３～１５５０Ｋ、Ｈ４では１５５０Ｋである。特にＨ４の合金粉末では液相に近い高温焼結で相対密度１００％が得られた。本発明により得られた焼結体の相対密度の一例を図２及び図３に示す。図２は表１の合金成分中のＨ２について粉粒径１０^1未満～１０^{-2}μmのＦｅ微粒粉（カーボニル鉄粉）を用い、その他の成分は各単独元素の粗粒粉を混合したときのＦｅ微粒粉の混合量と相対密度の関係を示したものである。この場合、１５０３Ｋ×７．２Ｋｓの固相焼結においてＦｅ微粉４０％質量％で相対密度１００％が得られた。

【００１２】図３は表１中の本発明に係わるＨ４の高合金工具鋼について、高合金工具鋼と同一成分の合金粗粒粉に高合金工具鋼を成分組成とする単独元素の７種の微粒粉を混合したときの相対密度の関係を示したものである。圧粉体の相対密度が８４％のものは、微粉末の混合量が２０質量％、５４％のものは４０質量％、焼結温度が１５２３Ｋ×７．２Ｋｓの固相焼結において、相対密度が１００％の焼結体が得られた。

【００１３】図４に示す顕微鏡組織写真は表１のＨ４成分組成の圧粉体密度８４％の高合金工具鋼を工具製品形状に成形した場合、真空焼結１５２３Ｋ，焼結時間７．２Ｋｓの焼結条件にて焼結したときの微粒粉の配合割合と空隙、空孔の発生、残留状況を示すものである。即ち、上段は各微粒粉の配合率に対応する焼結体のラップ加工面の状況、下段は腐食面を示す顕微鏡組織写真である。これによれば、微粒粉０％、１０％ものは空隙、空孔等（黒い部分）の残留が認められ、相対密度が１００％に達していないが、微粒粉が２０％、４０％では相対密度１００％が得られることが分かる。

【００１４】

【発明の効果】本発明は、上述のように粒径が10^1～10^3μm未満の高合金工具鋼の粗粒粉８０～２０重量％に、粒径が10^1未満で10^{-2}μmまでの高合金工具鋼の微粒粉を２０～８０％配合し、次いでこれを圧粉成形し、さらに真空雰囲気中で１５２３～１５５０Ｋｓの温度で約１２０分間固相焼結処理し、相対密度１００％の緻密特性を得たので、粉末冶金法の特徴である形状の自由度を利用して、直接に工具製品形状の工具を固相焼結することができる。しかも、焼結された高合金工具鋼は緻密化されたので、鍛造、圧延、機械加工を必要とせず、大幅なコスト低減が可能となった。さらに、結晶粒の粗大化や炭化物の溶融、凝集に伴う巨大炭化物の形成等の材料的な組織欠陥や、材料の強靭性及び工具性能を劣化させることもない。

【図面の簡単な説明】

【図１】表１に示す本発明に係わる各種の高合金工具鋼粉末について上段で相対密度５４質量％の、下段で８４質量％の各圧粉体のそれぞれの焼結温度と焼結体の相対密度の関係図である。

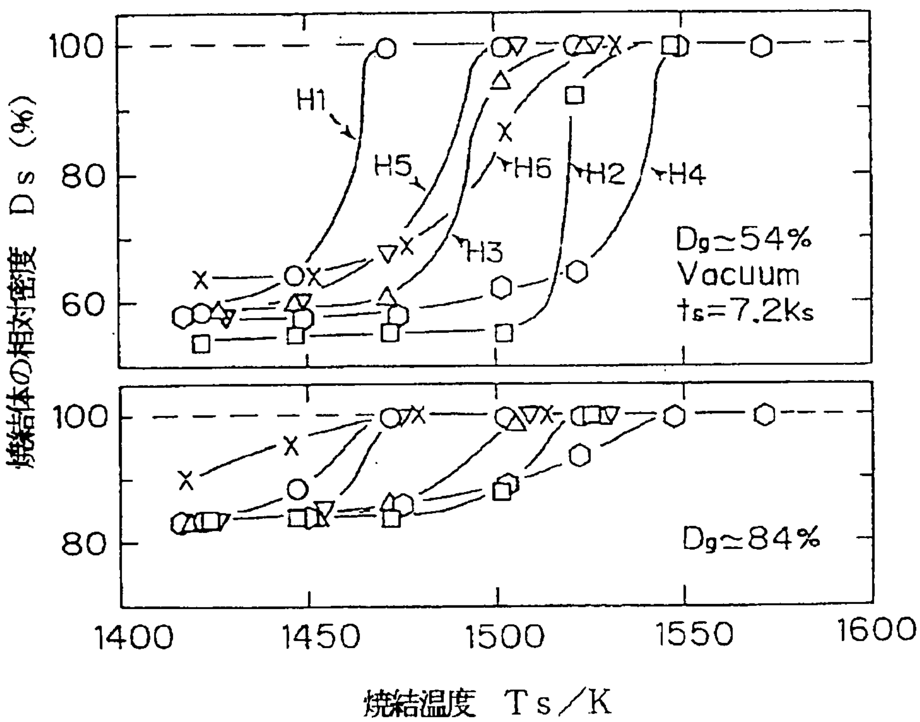
【図２】本発明により得られた焼結体の相対密度の一例

であって、表1の合金成分H2について粉粒径10^{1}～10^{-2} μm未満のFe微粉を用いた場合のFe微粉の混合量と相対密度の関係図である。

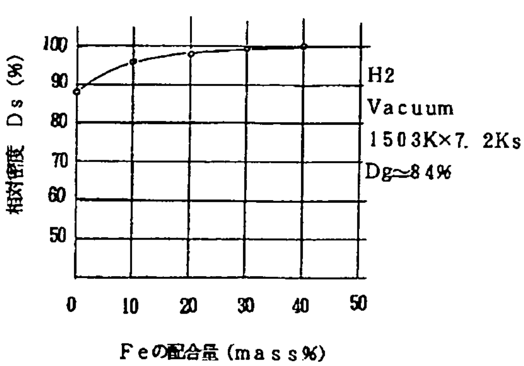
【図3】本発明に係わるH4の合金粉末の高合金工具鋼について、粗粒粉と同一成分の高合金工具鋼微粉を混合したときの相対密度の関係図である。

【図4】表1のH4の高合金工具鋼の微粒粉の種々の混合率におけるラップ加工面と腐食面の顕微鏡組織写真である。

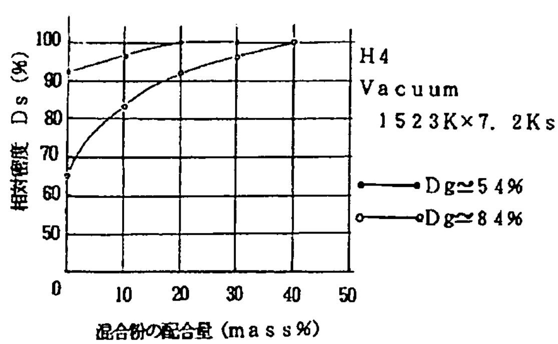
【図1】



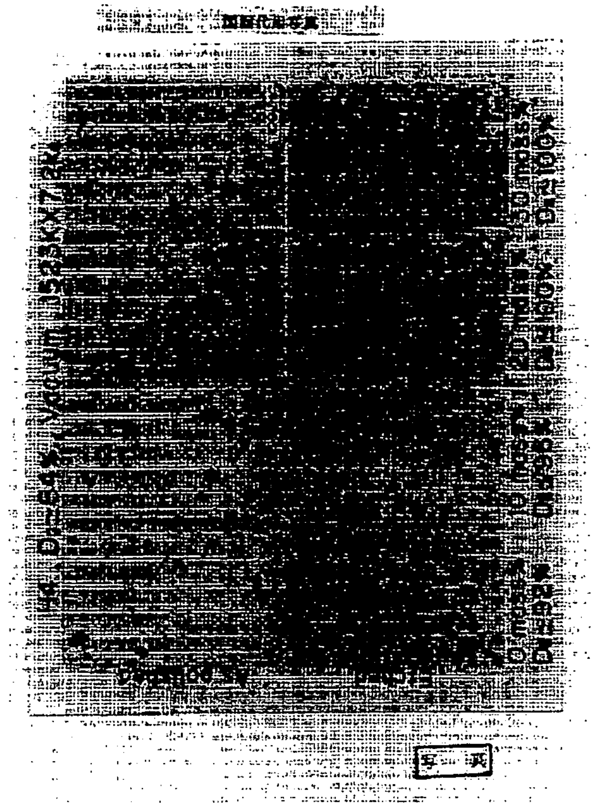
【図2】



【図3】



【図4】



【手続補正書】

【提出日】平成３年７月５日

【手続補正１】

【補正対象書類名】図面

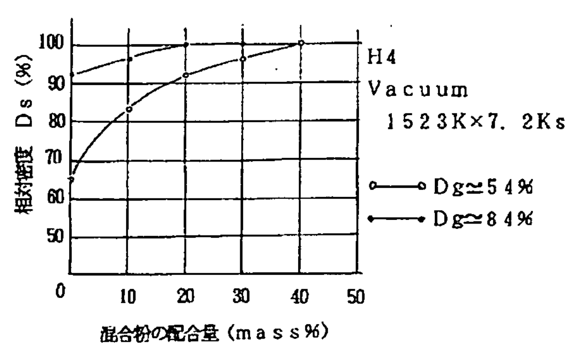
【補正対象項目名】図３

【補正方法】変更

【補正内容】

【図３】

【図3】



フロントページの続き

(72)発明者　山住　海守
富山県富山市石金20番地　株式会社不二越
内

19 Japan Patent Office (JP)

12 Japanese Unexamined Patent Application Publication (A)

11 Japanese Unexamined Patent Application Publication
Japanese Unexamined Patent Application Publication H5-9509

(43) Publication date January 19, 1993

51 Int. Cl.		Identification Symbol	JPO file number	FI	Technical indications
B 22 F	7/00	H	7803-4K		
	3/14		7803-4K		
C 22 C	38/00	302 E	7217-4K		
		304	7217-4K		
F 27 B	17/00	301 E	7308-4K		

Request for examination Not yet requested Number of claims 4 (Total of 6 pages)

(21) Patent Application No. Japanese Patent Application H3-187052

(22) Date of Application July 2, 1991

(71) Applicant 591162712
Koji Hayashi
297–1 Nisshin-cho, Omiya, Saitama Prefecture

(71) Applicant 000005197
Nachi-Fujikoshi Corp.
20 Ishigane, Toyama, Toyama Prefecture

(72) Inventor Koji Hayashi
297–1 Nisshin-cho, Omiya, Saitama Prefecture

(72) Inventor Michio Karaki
c/o Nachi-Fujikoshi Corp.
20 Ishigane, Toyama, Toyama Prefecture

(74) Representative Junji Kawauchi, Patent Attorney

Continue to the last page

(54) [Title of the Invention]

A high-alloy tool-steel sintered body and the manufacturing methods thereof

(57) [Abstract]

[Purpose]

To obtain a high-alloy tool-steel sintered body that has no defect in the structure of its materials, such as bulking up of crystal granules, and formation of enormous pieces of carbide caused by fusing and aggregating of carbide, and has no material defect, such as holes, after being sintered.

[Constitution]

A fineness of 100% relative density is obtained by including 20–80% of fine powder granules of high-alloy tool-steel with a granular diameter of less than 10^1 and up to 10^{-2} μm in 80–20 wt% of coarse-granule powder of high-alloy tool-steel with a granular diameter of 10^1–10^3 μm. Furthermore, the powder described above is formed by compressing and carrying out a solid-phase sintering process for approximately 120 minutes at a temperature of 1503–1573 K under a vacuum hood.

[Scope of Patent Claims]

[Claim 1]

A high-alloy tool-steel sintered body including 20–80% of fine powder granules of high-alloy tool-steel with a granular diameter of less than 10^1 μm and up to 10^{-2} μm, in 20–80 wt% of coarse-granule powder of high-alloy tool-steel with a granular diameter of 10^1–10^3 μm, and having a fineness of 100% relative density.

[Claim 2]

A method of manufacturing a high-alloy tool-steel sintered body characterized as having a fineness of 100% relative density by combining 20–80% of fine powder granules of high-alloy tool-steel with a granular diameter of less than 10^1 μm and up to 10^{-2} μm in 80–20 wt% of coarse-granule powder of high-alloy tool-steel with a granular diameter of 10^1–10^3 μm, then forming by compressing it, and further carrying out a solid-phase sintering process for approximately 120 minutes at a temperature of 1503–1573 K under a vacuum hood.

[Claim 3]

A method of manufacturing a high-alloy tool-steel sintered body according to Claim 2, wherein the fine powder is combined with the coarse-granule alloy powder of high-alloy tool-steel and an alloy powder with materials that are the same as coarse-granule powder, a type of single element during composition, or some type of fine powders mixed.

[Claim 4]

A method of manufacturing a high-alloy tool-steel sintered body according to Claim 2, wherein the fine powder of an alloy powder—in which the composition is the same as said mixed coarse-granule powder, a type of single element during composition, or a mixed fine powder in which more than two types of fine powders are mixed—is mixed with a mixed coarse-granule powder combined with the coarse-granule powder of a single element in the composition of the high-alloy tool-steel.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application]

The present invention relates to a high-alloy tool-steel sintered body for cutting tools affected by minor materials defects and the manufacturing methods thereof.

[0002]

To manufacture a high-alloy tool-steel sintered body by powder metallurgy method, it is manufactured by processing into a shape, such as round, square, plate, and line, or a desired tool shape by forming powder compacts using a CIP device and then sintering, or directly manufacturing sintering compacts using an HIP device and then carrying out a deformation processing (forging, flatting, etc.) for the sintering compacts. The reason why the deformation processing is required for such a high-alloy tool-steel sintered body is because sintering compacts usually have defects such as airspaces and holes and it is difficult to obtain perfectly fine sintering compacts. Therefore, it is necessary to facilitate perfect fineness with the improvement of defects such as airspaces by compressing these spaces and holes by carrying out deformation processing for such sintering compacts.

[0003]

For example, generally, a coarse-granule powder with a powder granular diameter of less than 10^1–10^3 μm or an ultra-fine powder or nano-fine powder with a powder granular diameter of 10^1–10^{-2} μm is independently used for material powder using the powder metallurgy method. Because coarse-granule powder easily develops airspaces when forming powder compacts, achieving perfect fineness is extremely difficult by removing airspaces when sintering. In addition, because the relative density of powder compacts becomes too high when ultra-fine powder forms powder compacts by themselves alone, isolated airspaces are easily formed and remain as fine holes after sintering.

[0004]

[Problem to be Solved by the Invention]

By nature, the most significant characteristic of the powder metallurgy method is high flexibility of shape. Therefore, forming a powder of high-alloy tool-steel for powder compacts in shapes such as, for example, round, square, plate, or a desired tool shape, such as a drill or end mill, is very easy. On the other hand, it is unavoidable that material defects such as holes remain in them by sintering. However, perfect fineness by removing these defects is very difficult; chipping and deficiencies based on material defects are issues for use in cutting tools, and significant tool performance cannot be expected. Therefore, almost no sintering compacts in the shape of tool products are put into practical use in reality.

[0005]

On the other hand, setting the sintering temperature high after forming powder compacts shows a tendency to decrease defects such as holes, and almost no air holes are found in liquid-phase sintering, and it is possible to obtain sintering compacts with a relative density near 100%. The strength of materials and tool performance, however,

deteriorates because of defects in the structure of its materials by making crystal granules bulk up or forming enormous pieces of carbide caused by fusing and aggregating of carbide. Moreover, because high-alloy tool-steel improves defects such as airspaces when carrying out the deformation processing such as in said prior art, the yield of materials is negligible, and it requires a number of processing processes, with the problem of increased high costs.

[0006]

[Means for Solving the Problem]

The present invention relates to a manufacturing method for a high-alloy tool-steel sintered body characterized by obtaining a fineness of 100% relative density by including 20–80% of fine powder granules of high-alloy tool-steel with a granular diameter of less than 10^1 and up to 10^{-2} μm, in 80–20 wt% coarse-granule powder of high-alloy tool-steel with a granular diameter of less than 10^1–10^3 μm, combining 20–80% of fine powder granules of high-alloy tool-steel with a granular diameter of less than 10^1 μm and up to 10^{-2} μm, with 80–20 wt% of coarse-granule powder of high-alloy tool-steel with a granular diameter of less than 10^1–10^3 μm, and then forming by compressing it, and further carrying out a solid-phase sintering process for approximately 120 minutes at a temperature of 1503–1573 K under a vacuum hood.

[0007]

The reason why the coarse granular diameter is less than 10^1–10^3 μm in the present invention is because the structure, pieces of carbide, and crystal granules are enormous if it is greater or equal to 10^3 μm, and this causes deterioration in the strength of materials. Furthermore, the reason why the fine granular diameter is less than 10^1 and up to 10^{-2} μm is because 10^{-2} μm is a threshold limit that can be technically manufactured.

[0008]

[Embodiment]

Next, an embodiment related to the present invention is described. Fig. 1 shows various high-alloy tool-steel sintered body powders in which the elements of high-alloy tool-steel of comparatively coarse-granule powders of various alloy powders, shown in H1 through H6 in Table 1, are mixed. The top of Fig. 1 shows the relationship between the sintering temperature for powder compacts with a relative density of 54 wt%, and the relative density of sintering compacts, and the bottom of Fig. 1 shows the relationship between the sintering temperature of powder compacts with a relative density of 84 wt%, and the relative density of sintering compacts. For both, the solid-phase sintering process has been carried out for 120 minutes with the degree of vacuum 9×10^{-1}–10^{-5} in a vacuum furnace.

[0009]

The relative density of sintering compacts depends on the element composition and density of powder compacts, but in powder compacts of 54% density, sintering compacts to 100% relative density can be obtained at sintering temperatures: H1=1473 K, H2=1547 K, H3=1523 K, H4=1550 K, H5=1503 K, H6=1533 K, and in powder compacts of 84% density, sintering compacts with 100% relative density can be obtained at sintering temperatures: H1=1473K, H2=1523 K, H3=1503 K, H4=1547 K, H5=1503 K, H6=1473 K. This shows that, except for the H1 and H5 elements, a higher density of powder compacts can obtain sintering compacts with a higher relative density at lower sintering

temperature. In addition, it also shows, at the same time, the tendency in which higher sintering temperature results in higher relative density, and it is thought that the liquid-phase temperature of the element composition is involved. For comparison, the solid-phase sintering process has been carried out in a hydrogen atmosphere. The values reached saturation or maximum relative density of 95–97%, and the remaining small amounts of isolated airspaces have been confirmed.

[0010]

[Table 1]

Alloy powder		Fe	Co	C	Cr	Mo	W	V	TiN
H1	○	73.63	7.87	1.24	3.90	9.79	1.60	1.19	–
H2	□	79.14	0.56	1.33	3.97	5.57	5.78	3.07	–
H3	△	71.76	8.22	1.35	3.99	5.13	6.25	2.67	–
H4	⬡	70.65	5.02	1.78	4.09	0.40	12.48	4.88	–
H5	▽	62.03	9.40	2.86	4.01	3.45	9.38	8.31	–
H6	×	53.41	8.46	3.05	4.05	3.23	9.76	7.54	10

[0011]

Sintering temperatures that reach 100% relative density depend on the element composition, but it is 1523–1550 K when the alloy powder of H2 in Table 1 is sintered, and 1550 K in H4. Especially, with the alloy powder in H4, 100% relative density can be obtained at a high temperature that is close to the liquid-phase. Examples of the relative density of sintering compacts obtained by the present invention are shown in Fig. 2 and Fig. 3. Fig. 2 shows the relationship of the amount of an Fe fine powder granule mixture and the relative density when the Fe fine powder granules (carbonyl iron powder) with a powder granular diameter of less than 10^{1}–10^{-2} μm are used for H2 in the alloy element in Table 1 and coarse-granule powder of each single element is mixed for other elements. In this case, 100% relative density can be obtained with 40 wt% of Fe fine powder in the solid-phase sintering process at 1503 K × 7.2 Ks.

[0012]

Fig. 3 shows the relationship of relative densities when mixing seven types of fine powder granules for a single element in which the high-alloy tool-steel is used as an element composition, in an alloy coarse-granule powder in which the elements are the same as high-alloy tool-steel for the high-alloy tool-steel in H4 related to the present invention in Table 1. In solid-phase sintering at sintering temperature of 1523 K × 7.2 Ks, sintering compacts with a relative density of 100% can be obtained in the following conditions: 84% relative density of powder compacts with 20 wt% of a mixture of fine powder, and 54% relative density of powder compacts with 40 wt% of a mixture of fine powder.

[0013]

The picture of the microscope structure shown in Fig. 4 shows the composition rate of fine powder granules, airspaces, the occurrence of airspaces, and the residual status when sintering under the sintering conditions of 1523 K vacuum sintering and 7.2 Ks sintering time if a high-alloy tool-steel with a powder compact density of 84% of H4 element composition in Table 1 is formed into a tool product shape. This means that the top is the status of a wrap process surface of sintering compacts corresponding to the composition rate of each fine powder grain, and the bottom is a picture of the microscopic structure showing a corrosion surface. According to this, the remaining airspaces and holes (black parts) are seen for 0% and 10% fine powder granules, and relative density does not reach 100%. However, with 20% and 40% fine powder granules, 100% relative density can be achieved.

[0014]

[Effect of the Invention]

In the present invention, because, as described above, a fineness of 100% relative density was obtained by combining 20–80% of fine powder granules of the high-alloy tool-steel with a granular diameter of less than 10^1 and up to 10^{-2} μm in 80–20 wt% of coarse-granule powder of high-alloy tool-steel with a granular diameter of less than 10^1–10^3 μm, and then forming by compressing it, and carrying out a solid-phase sintering process for approximately 120 minutes at a temperature of 1523–1550 Ks under a vacuum hood, solid-phase sintering can be directly performed for tools with a tool product shape by using the flexibility of shapes that are characteristic of the powder metallurgy method. Moreover, because sintered high-alloy tool-steel has been refined, significant cost saving is possible without forging, rolling, and machinery processing. Furthermore, there are no defects in the structure of materials and no deterioration in the strength of materials or tool performance by forming enormous pieces of carbide caused by making crystal granules bulk up or fuse and by aggregating of carbide.

[Brief Description of the Drawings]

[Fig. 1]

A relation diagram of the sintering temperatures of each powder compact with a relative density of 54 wt% (upper side) and a relative density of 84 wt% (lower side) for various high-alloy tool-steel sintered bodies related to the present invention shown in Table 1 and the relative density of sintering compacts.

[Fig. 2]

This is an example of the relative density of sintering compacts obtained by the present invention and a relation diagram of the amount of the mixture of Fe fine powder and the relative density when Fe fine powder having a powder granular diameter of less than 10^1–10^{-2} μm is used for the alloy element H2 in Table 1.

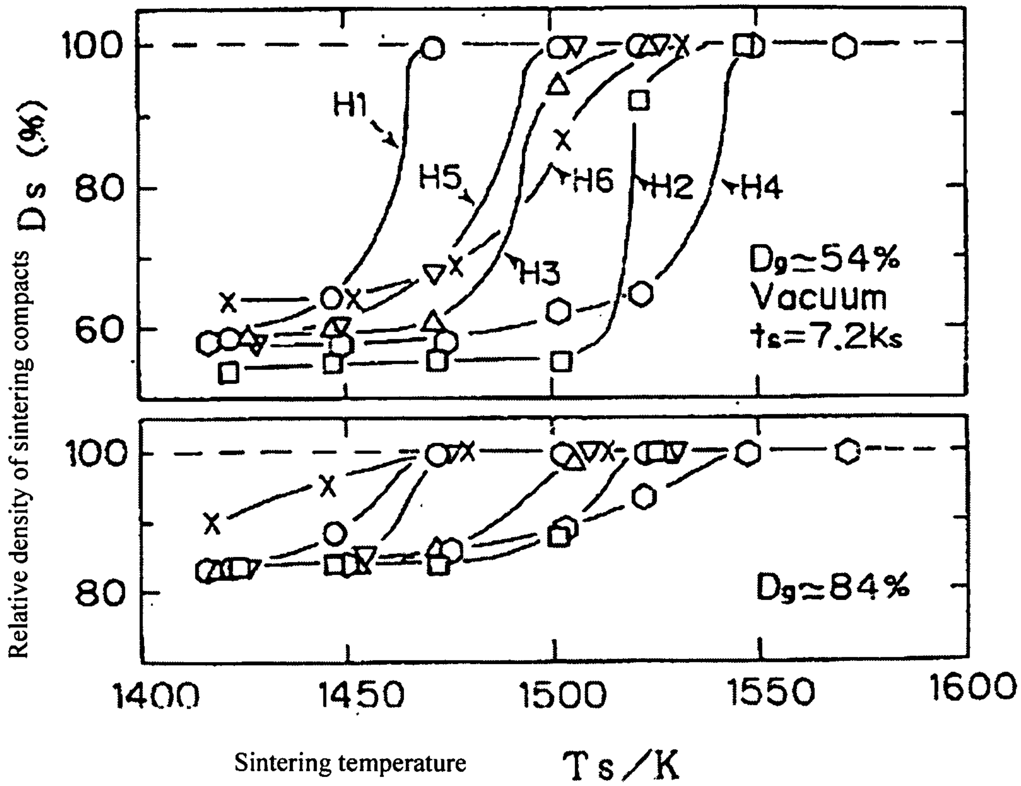
[Fig. 3]

A relation diagram of relative density when the high-alloy tool-steel fine powders in which the elements are the same as coarse-granule powder are mixed for the high-alloy tool-steel of the alloy powder of H4 related to the present invention.

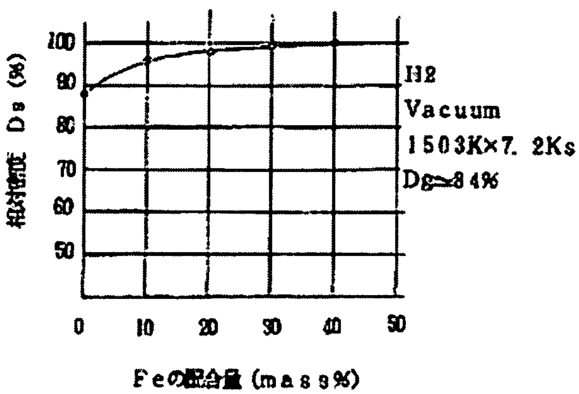
[Fig. 4]

A picture of the microscope structure of the wrap processing surface and the corrosion surface for various mixture rates of fine powder granules of the high-alloy tool-steel of H4 in Table 1.

[Fig. 1]

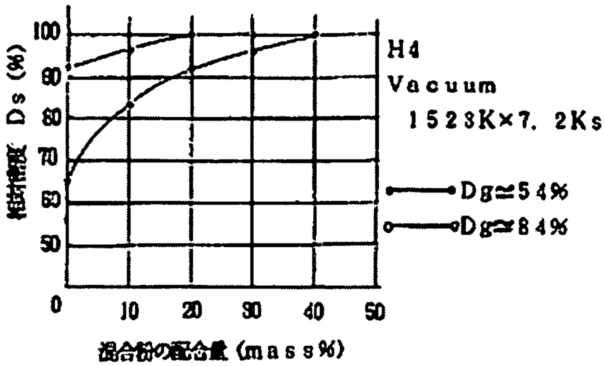


[Fig. 2]



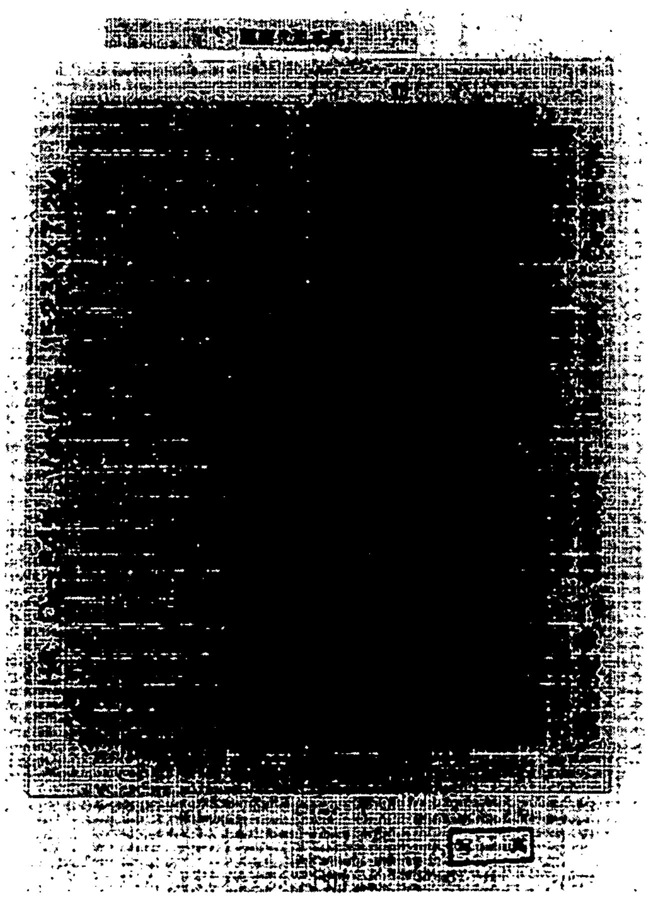
Japanese	English
相対密度	Relative density
Fe の配合量	Amount of composition of Fe

[Fig. 3]



Japanese	English
相対密度	Relative density
混合粉の配合量	Amount of composition of mixed powder

[Fig. 4]



Japanese	English

図面代用写真	Picture substitute for drawing
写真	Picture

[Procedure correction]

[Submit date] July 5, 1991

[Procedure correction 1]

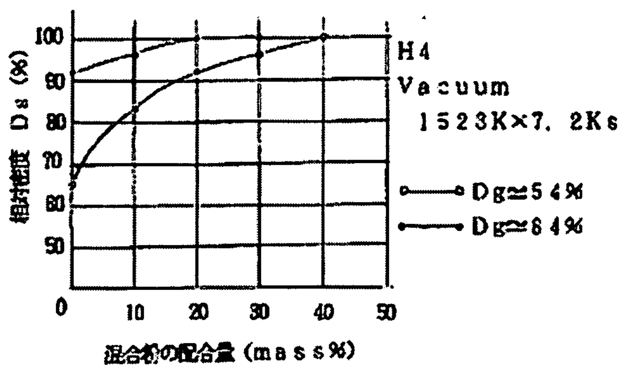
[Document title for correction] Drawing

[Item name for correction] Fig. 3

[Correction method] Modification

[Correction content]

[Fig. 3]



Japanese	English
相対密度	Relative density
混合粉の配合量	Amount of composition of mixed powder

Continued from the front page

(72) Inventor: Umimori Yamazumi

c/o Nachi-Fujikoshi Corp

20 Ishigane, Toyama, Toyama Prefecture